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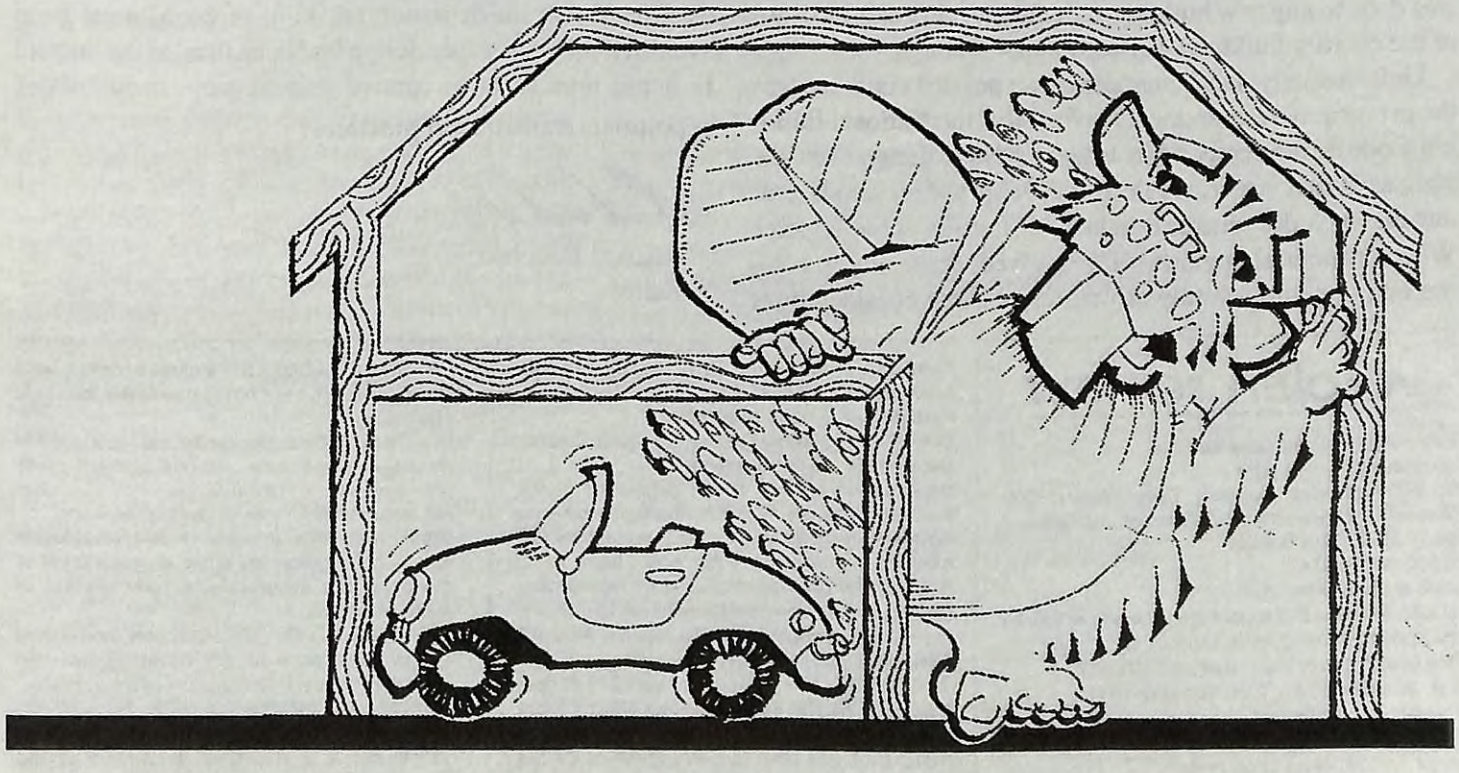
Attached Garages and Indoor Air Quality



From the Editor . . .

The earth shook recently in this area of high seismic risk. Because earthquakes do not occur often here on the West Coast of Canada, we feel uneasy when one does happen. Unlike the case of severe storms, there is no advance warning or any indication of how severe the quake will be. As the severity of the quake increases, so does the damage and the list of casualties.

There have been several severe earthquakes with many casualties in populated areas this year, but these have occurred somewhere else. Although here on the West Coast we live in the most seismically active region in the world, the quakes were a world away. We could afford to sympathize, and were ultimately complacent.

With its epicentre so close to home, this earthquake was felt throughout the region. Questions are being asked: Just how safe are we? Will our buildings and bridges withstand the "big one" we are reminded will happen at some point in time? Is there any way we can prepare?

Although you can't really be sure you will be ready for an earthquake, and living through a tremor may be unnerving, you can prepare for and survive it.

Building codes, design and construction practices have changed over the years. After every earthquake, teams of engineers study how structures stood up, where failures took place, and how effective standards were. Today's design standards are now sufficiently high that little severe damage was done to any new building in Seattle, while many old, turn of the century buildings suffered major damage.

Unfortunately, local engineers have pointed out to me that the prescriptive requirements in Part 9 of the National Building Code do not really address good seismic design. Yes, the code says that structures must meet appropriate conditions, and that includes seismic design in seismically active regions. Where structural engineers are involved, especially in commercial and multi-family structures, seismic considerations always get full review and design. So any building designed under Part 4 (structural design) requirements of the code should be able to withstand most earthquakes. However, this is not the case for single family houses, which usually do not get the full engineering treatment.

I have heard builders complain about "overkill" when engineers require upgrades to their structures to meet good seismic design. The most commonly voiced complaint is that seismic design adds to the cost of construction, and that seismic restraint will affect the affordability of new homes. In fact, the most commonly used suburban designs, with their large open areas (e.g., double garages), are inherently poor seismic designs unless specially reinforced – which most are not.

What is the real cost of doing things properly? Why do we allow adequate seismic design to be considered an option - as in practice it now is? Is it really an option? Just because a severe earthquake happens so infrequently, is it acceptable to ignore the possibility? Is ignoring adequate seismic design in seismically active areas not a big game of Russian roulette?

We have seen building envelope failures in many places around the world. Is this also a luxury that well informed consumers must ask for specifically, rather than expect adequate performance?

I wonder what will happen if a big earthquake does strike. Will we see our industry once again tarnished when it is discovered that much structural damage could have been avoided if proper seismic design had been used at the outset? Is it not time to be proactive and to get serious about appropriate construction practices?

Richard Kadulski,
Editor

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Attached Garages and Indoor Air Quality

Up to 85% of outdoor air leaking into a house can enter through the garage, bringing with it garage air pollutants.

We spend 90% of our time indoors, so we have to consider how a home's design and construction can affect indoor air quality. To achieve superior indoor air quality it is important to:
- *remove any contaminants at the source of production;*
- *reduce the contaminants built into the house;*
- *exchange the indoor air with fresh outdoor air.*

Perhaps because of our harsh northern climate, or because we have become such slaves to creature comfort, most new homes have attached garages. However, garages are a source of deadly pollutants: car-starts produce carbon monoxide (CO); stored fuels release benzene; and other materials leak volatile organic compounds.

To prevent problems, the wall between the garage and the house must be built airtight. The Building Code requires that the construction between a garage and a dwelling provide an effective barrier to gas and exhaust fumes. It is "intended to provide reasonable protection from carbon monoxide and gasoline fumes entering the dwelling unit."

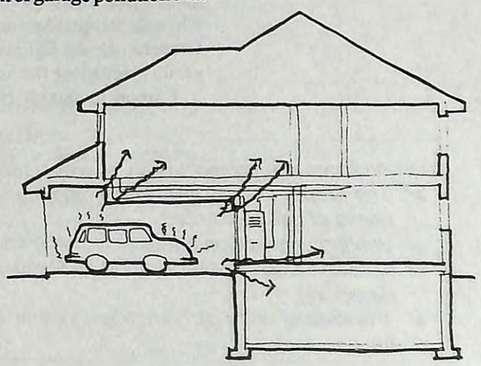
Two coroner's reports on deaths caused by CO leakage from attached garages suggested that the building code's notion that the separation between the house and the garage acts as a gas-tight barrier is largely a myth. In practice, it is hard to form an airtight seal in the elements between the house and the garage. We now have evidence that leaks through the wall and ceiling between the garage and the house allow garage air pollutants to enter the house. Studies are finding that from 5% to 85% of the outdoor air leaking into a house comes through the garage and carries carbon monoxide and other contaminants into the house. Houses with attached garages typically have gasoline concentrations that are 10 times higher than outdoor levels, sometimes as much as 50 times higher.

The largest, single indoor air quality concern with an attached garage is that the garage is a source of CO entering the house. Even the Committee that drafts the National Building Code has recognized that the notion of the separation between the house and the garage acting as a gas-tight barrier is largely a myth, but has not been able to find a way to solve the problem. The CMHC and the American Lung Association suggest that, for optimum indoor air quality conditions, garages should be built detached from rather than attached to the house.

In the past, builders rarely worried about the airtightness of the houses they built. Standard construction practices would produce a house that generated few if any complaints related to airtightness, such as moisture on windows or stale odors. By building houses with a significant amount of air leakage, builders were actually incorporating a passive ventilation system into every house they built. The low efficiency, natural-draft combustion appliances acted like exhaust fans drawing large quantities of outside air into the house. This passive ventilation system was crude, uncontrollable, and created comfort complaints, but it did satisfy the ventilation needs of most houses built more than two decades ago.

However, dilution with outside air in a "loose" house is an inefficient method of removing pollutants. For toxins such as CO, providing more outside air as long as it is still being produced, is dangerous. Even with high volumes of dilution air, the air quality is degraded when pollutants are dumped into a space. High volumes of dilution air also greatly increase heating and cooling costs.

Several studies in the U.S. and Canada have been looking at the amount of garage pollution that enters the house, and what the pollution driving mechanisms are.



When it starts, an automobile generates CO, and should not be allowed to idle inside the garage, even when the garage door is open. Starting a cold car in a garage can send CO levels soaring to more than 80,000 parts per million (ppm) in seconds. In addition, the automobile will offgas a

whole range of fumes, especially as it cools down after use. As the CO leaks into the house it is diluted, so CO concentrations in the house will be lower than in the garage, but can still be at unsafe levels. It can take several hours for CO concentrations in the home to reach safe levels.

Twelve Anchorage area houses with attached garages were studied to assess carbon monoxide movement from the garage into the house. Data was recorded for normal living patterns. One and two-storey homes, with one-, two-, and three-car attached, heated garages were examined. The common surfaces included wall and ceiling areas ranging from 164 to 772 square feet. Results were used to calculate residents' exposure to CO.

It was found that CO from car-starts in the garage entered all but one of the houses. In four of the twelve houses, the exposure was 60% or more of the EPA exposure limit for ambient air, and in one case carbon monoxide exceeded the EPA limit. Exposure at the EPA limit can result in a carboxyhemoglobin level in the bloodstream at which the at-risk population (e.g., angina patients) begin to exhibit adverse symptoms.

In all but one of the houses, the house was at a lower pressure than the garage, thus sucking in garage pollutants.

Carbon Monoxide

Carbon monoxide is a colorless, odorless, tasteless, non-irritating, and highly toxic gas produced when carbon-based fuels burn incompletely. Complete combustion of carbon and oxygen produces carbon dioxide ($C0_2$), a non-toxic gas. Incomplete combustion happens when there is insufficient combustion air, insufficient time for complete combustion, incomplete mixing of air and fuel, or when the temperature drops below the combustion temperature. As CO is lighter than air, it moves easily throughout the house.

Carbon monoxide is absorbed rapidly by the lungs and quickly passes into the blood. Carbon monoxide replaces oxygen in the bloodstream, causing CO intoxication and a lack of reasoning.

Carbon monoxide poisoning can be prevented by:
- ✔ *The proper design, installation, and maintenance of gas appliances.*
- ✔ *Venting combustion products to outdoors.*
- ✔ *Installing warning devices (carbon monoxide detectors).*
- ✔ *Preventing entry of garage gases into the house*

The affinity of CO and red blood cells (hemoglobin), is 200 to 270 times greater than the affinity of oxygen and hemoglobin. Hemoglobin carrying CO (carboxyhemoglobin) is not able to release oxygen to the tissues. Even small amounts of carbon monoxide in the air breathed will quickly increase the percentage of carboxyhemoglobin. Mild CO poisoning feels like the flu, but more serious poisoning can lead to breathing difficulty and death. Just how sick people get from CO exposure varies greatly from person to person, depending on age, health, concentration and length of the exposure. High concentrations are dangerous even for a short time.

Carbon monoxide is the leading cause of poisoning deaths in the U.S., where 3,500 to 4,000 people die annually, and an estimated 10,000 people lose a day's work or seek medical attention. Fires are the main cause of the fatalities, but automobile exhaust in attached garages and faulty heating equipment cause about one-third of the deaths. Canadian numbers would be similar, in proportion to our population.

However, the true incidence of CO exposure is unknown and may be greatly underestimated because CO exposure can be easily misdiagnosed. In a 1995 incident in Ohio, five persons went to the local hospital with flu-like symptoms. Relatives asked the doctor three times if the cause could be carbon monoxide poisoning, but he said no, it was the flu. The family was sent home and three days later all five died of carbon monoxide poisoning. A Kentucky study found that 23.6% of persons showing up at a hospital during February 1985 had elevated carboxyhemoglobin concentrations. None were initially diagnosed as suffering from carbon monoxide poisoning.

Attached garages increase CO problems in the home because houses are kept closed during winter, reducing air change to the outside, and keeping more CO inside for longer periods. In cold weather, vehicles also tend to be warmed in the garage for longer periods.

Cold engines produce higher concentrations of carbon monoxide for longer periods. In a cold start, the engine is cold but the fuel mixture is rich (causing more CO). The catalytic converter is also cold and ineffective. Even well-tuned engines will produce more than 80,000 ppm for the first minute or two of operation. The CO concentration will drop to 1,000 ppm or less after 5 to 15 minutes running time.

The rate of emission from a typical gasoline engine can be so high (30,000 to 100,000 ppm) that it is difficult to provide adequate ventilation. In one test, a 5.5 horsepower, gasoline-powered pressure washer was run in a double garage with both doors and windows open, and an open vent. Within 12 minutes, CO concentrations in the garage rose to 658 ppm.

Air Tight Construction Practices

How can one protect against carbon monoxide and other pollutants from the garage entering the house? There is no safe way other than building a detached garage.

Second best is to seal the walls and doors to the house tightly, or to use an exhaust fan in the garage. A garage exhaust fan can prevent CO from entering the house. A properly-sized fan venting to outdoors will lower the pressure in the garage, prevent CO from entering the house, and speed the removal of CO. However, the fan could depressurize the house. Vented appliances (furnaces, water heaters, and boilers) must be checked for proper operation after a garage fan is installed. Even with a garage fan, running an engine in the garage is unsafe.

Since carbon monoxide does not attach itself to surfaces in the garage, a complete air change will remove all the CO. With doors on opposite sides of the garage open, this will probably take 5 minutes or less. With doors open on only one side, it will take longer and vary depending on wind and air flow.

What is more disturbing is how often heating and ventilating equipment is placed in the garage, or in a space accessible only through the garage. The problem exists whether the heating system is forced warm air with ducts or hot water with piping in the garage. Observations have found especially high levels of CO transfer into the house when forced-air heating systems are located in the garage.

If the house pressure is at a lower pressure than the garage, air from the garage will flow into the house.

The Healthy House Book

While there have been significant strides toward improving some facets of the environment, the air quality inside our houses is almost always more polluted that the air we breathe outdoors. The reasons for this are sometimes simple, sometimes complex. But the good news is that there are solutions.

For more than a decade the standard reference book for information on the health effects of building materials and for locating less-toxic alternatives has been ***The Healthy House*** book. Now in its 4th edition, it contains much more information than the original 1989 edition. Besides being revised, expanded, and updated, it now also contains articles by 50 healthy house professionals from across North America.

The book contains addresses, phone numbers, and web sites for more than 600 organizations and suppliers, and with more than 1,300 references to more in-depth information, no other book on the subject matches its completeness.

Author John Bower has been a house designer, home builder, consultant, writer, and lecturer promoting healthier construction practices since 1984.

The Healthy House: How to buy one, How to build one, How to cure a sick one
by John Bower 448 pages, US $ 23.95
The book can be ordered directly from the Healthy House Institute or through bookstores.
Tel./fax: 812-332-5073 or: www.hhinst.com

You asked us about: Exterior insulation and rain screens

I want to build a durable, energy-efficient house on the West Coast. I also want to use rigid exterior insulation to reduce thermal losses. However, I don't have any experience with the system and want to avoid an EIFS (exterior insulated face-sealed) problem.

The wall system under consideration is, inside to outside:

- *drywall with vapour retarder paint*
- *2x6 studs with R-20 blown-in fiberglass*
- *OSB structural sheathing*
- *building paper*
- *1 inch (R-5) extruded polystyrene insulation, with horizontal and vertical joints taped*
- *1x2 furring strips*
- *wood siding*

Around windows the detailing would be 1" blocking in place of the rigid insulation to provide a nailing surface for the window flange.

I am concerned that liquid water or water vapour that gets behind the extruded insulation will not be able to dry to the exterior or interior.

The fundamental issue is how to manage exterior moisture. To start with, we have to approach building envelope design with the assumption that all cladding materials will leak at some time. Water has to have a way to get out and the materials have to be able to dry out.

In theory, there is nothing wrong with EIF systems provided they are installed and detailed correctly for their application. EIFS, face-sealed finishing systems, require a perfect exterior that will be able to resist water penetration - which is a practical impossibility. Where problems have arisen, they have largely been due to poor application details and sometimes to inappropriate use of materials and designs.

What you are proposing is a rain screen, where the first line of defence is the exterior siding which acts like the umbrella. What you describe makes a lot of sense. Variations are being used as a solution to many leakage and moisture problems. In fact, a rain screen is now a mandatory construction practice in the Vancouver area (but not rigid insulation, which is a thermal bonus).

The rain screen cavity provides drainage for any water that penetrates the siding. The vented cavity promotes drying. While the cavity between the siding and insulation provides an environment in which decay-producing organisms can grow, it is insects that may be the problem, and not decay organisms. A dry environment does not have conditions for decay organisms to grow. That is why insect screens have to be used for the cavity at the base of all cavities.

If carefully installed, a rain screen reduces the potential for moisture to get behind the extruded polystyrene. The most vulnerable places are around windows, doors and other penetrations. Care with flashing detail design during construction should take care of this.

Once the envelope is airtight, you have eliminated most of the driving force for moisture migration. Diffusion of vapour is a very small force, especially in the mild climatic conditions of the West Coast. With the extruded polystyrene, your first condensing plane is warm, so even if there is some moisture within the wall cavity, you are reducing the chances for condensation. By using a vapour retarder paint, there is still the possibility for a small amount of water vapour diffusion into, and out of, the wall assembly, so small amounts of moisture driven by diffusion into the construction will be able to dry out.

It is legitimate to be concerned about the extruded polystyrene on the outside acting a vapour barrier. However, the vapour barrier does not have to be on the inside surface. In fact, the Building Code provides a formula for placing the vapour barrier within an assembly. It is dependent on the climate conditions.

The actual weather barrier is the building paper. Because it is well protected, the paper would not likely see any moisture. If the interior drywall is properly air sealed, you should not need to tape and seal the polystyrene.

There is a more detailed discussion of this issue in ***The Best Practice Guide: Wood Frame Envelopes in the Coastal Climate of British Columbia*** *published by Canada Mortgage and Housing Corp. 1-613-748-2003; or www.cmhc-schla.gc.ca This publication provides much basic information on the issues, and some typical construction details.*

Heat Recovery Ventilators: Can they be a source of pollutants?

To ensure good indoor air quality, ventilation must be effective. Although there are a variety of ventilation systems in use, the heat recovery ventilator (HRV) has emerged as possibly the most effective and energy efficient system. The HRV is most efficient when used with good quality equipment. However, in most houses, almost no attention is paid to the maintenance or overall condition of the ductwork or cores in these systems.

Concerns have been raised that there may be unhealthy levels of dust and other particulate matters due to inefficient or poorly maintained filters in the HRV, and the growth of mould due to warm, humid air in the ductwork.

The highest numbers of installed balanced supply and exhaust ventilation systems per capita in Canada are found in the Atlantic Region. In Nova Scotia, several companies exclusively provide design and installation services for dedicated balanced ventilation systems.

Several Nova Scotia houses were studied to find out if dedicated ventilation systems can harbour unhealthy levels of dust and mould. Samples from the ductwork and HRV were tested for dust and mould levels. In addition, the study investigated if existing duct cleaning methods were successful at lowering dust levels.

Conventionally-built and R-2000 houses were studied. All were quite airtight (the leakiest was 3.9 ACH @50 Pa), and all had non-forced air heating systems. Forced air heated homes were avoided so that the effect of dedicated ventilation systems could be studied.

None of the conventional houses met the CSA F-326 standard requirements for Minimum Ventilation Capacity (MVC), and only a few would meet the installation requirements. Undersized kitchen exhaust ducts and no filters were the consistent deficiency. The ventilation systems in the R-2000 homes had been installed according to F326 requirements and had been inspected. However, air flows in some did not meet the current F326 requirements.

It was found that homeowners generally are not well informed about what the HRV does, how to use its controls (other than on/off switches), and how to maintain the machine to optimize its performance. Mould counts were high in the ductwork and cores, with consistently higher counts in the fresh air supply duct to the HRV (typically, a length of flex duct). However, there was no correlation between the levels of surface mould concentrations in the ducts and the air samples taken in the house. Thus it could not be determined if airborne moulds were a health risk in the houses tested.

In most of the conventional houses there were no filters on exhaust grilles in kitchens and bathrooms. The R-2000 houses had filters on the exhaust grilles in kitchens, but only one house had filters in the bathroom. In general, the HRV air flows were out of balance.

Cleaning the ducts had little impact on air flows. It was noted that current duct cleaning methods are not adequate for cleaning duct work in central ventilation systems. The success of cleaning was dependent on where the air wash was placed and how accessible the ducts were. Both portable and truck-mounted duct cleaning units cleaned only 50-60% of the visible dust.

Homeowners don't understand what an HRV does, how to run controls, and how to maintain the machine.

Recommendations were made by the study team include the following points.

HRV manufacturers and standards committees should consider ways of keeping HRV ductwork clean, including: a quick release duct to HRV connections, a restriction on the use of flex ducting, an outdoor filter on the fresh air supply, a higher ground clearance requirement for the fresh air supply inlet, and pre-filters on HRV exhaust duct terminations in the house.

Ductwork from the exterior fresh air supply hood to the HRV should be solid rather than flex, and should be installed in such a way that the duct can be easily cleaned. HRV ducting attachments would be easier to clean if there was a 'quick release' or other means of attachment.

HRV exterior fresh air hoods should contain a pre-filter and be accessible for cleaning

Exterior fresh air hoods should be installed at least 48 inches (1200 mm) above finished grade so that the intake air is above the height of outside mould spore dispersal from sources such as garden beds, lawns, bare soil under decks, etc.

Identifying and Removing Pollutants from Heat Recovery Ventilators
by Terry Watters
Sustainable Housing and Education Consultants Ltd
for CMHC Research Division

Pre-filtering of all exhaust grilles should be considered.

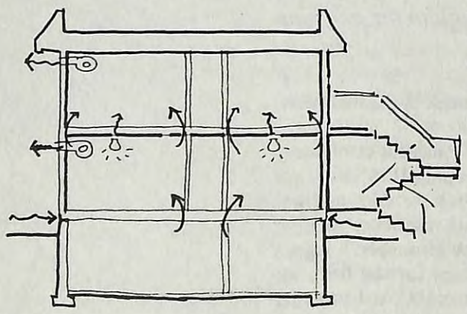
Homeowners need to be instructed on or reminded about maintenance requirements for their HRVs.

More promotion must be done about the information available to homeowners on maintaining HRV systems. One example is to make NRCan and CMHC publications available through HRV supplier/installer operations, local CHBA offices, CMHC offices and provincial departments and agencies that deal with housing and/or energy use.

Ventilation in Small Multifamily Buildings

The renovation market in Canada is outpacing the new construction market. Renovations also provide an excellent opportunity to promote energy efficiency.

There is large potential for energy savings in older multifamily buildings, which are poorly insulated and not airtight. These buildings typically have no mechanical ventilation and rely on air leaking through the exterior envelope to provide adequate air exchange. Ventilation in multifamily buildings depends on both the exterior leakage area and the airtightness between dwellings.



Ventilation in 2 or 3-unit Multifamily buildings before and after weatherization
Dino Gerbasii
SIRICON+
for CMHC Research Division

What happens when air sealing and insulation at or near the ceiling/roof junction are done? Is exhaust-only mechanical ventilation effective in small multifamily buildings after they have been retrofitted?

To provide minimum recommended fresh air flows, weatherization programs often rely on exhaust-only mechanical ventilation to compensate for the reduction in fresh air flows caused by draft proofing and upgrading of insulation. Although exhaust-only mechanical ventilation may be suitable for single family houses that have no risk of combustion spillage or backdrafting, this may not be the case in multifamily buildings. Codes or standards do not deal with ventilation requirements for retrofitted buildings.

Draft proofing the building can greatly reduce the equivalent leakage area of the exterior shell and change the location of the neutral pressure plane, which will alter the pattern of the passive air change. In many buildings, the leakage area is concentrated near the ceiling, which causes the neutral pressure plane to be at or near the top of the building. For this reason, even the top floor units may usually be under negative pressure and receive a substantial quantity of fresh air. This has a major impact on the outdoor air supply and how it is distributed on a unit-per-unit basis.

Quantifying fresh airflows in multifamily buildings is a more complex issue. Installing exhaust fans does not automatically ensure adequate outdoor air supply to individual dwellings. If outdoor air requirements are to be met with exhaust-only fans, it is important to understand how the fan affects air movement in the multifamily buildings in order to calculate how much fresh air is actually supplied to individual dwellings.

A study by Siricon for CMHC looked at the outdoor air supply for a 2-unit building before and after weatherization and evaluated the effectiveness of exhaust-only ventilation. The building type studied is a 2-storey up-down duplex typical of the buildings targeted by recent energy retrofit programs in Quebec. Simulations were done to evaluate the impact of air sealing and the effectiveness of exhaust-only mechanical ventilation.

A common energy retrofit for these buildings consists of insulating and sealing the roof cavities. Insulating and air sealing has a dramatic impact on natural air changes and how fresh air is distributed to the units. The neutral pressure plane is lowered and this leads to a decrease in fresh air for the upper floor unit, giving rise to potential indoor air quality problems.

The National Building Code ventilation requirements are based on the CSA F326 standard, which states that each dwelling unit must have a mechanical ventilation system with the capacity to supply outdoor air at a rate of the greater of either 0.3 ACH or the sum of individual room requirements. The ventilation system must be capable of running continuously and must supply a minimum amount of outside air to each of the main rooms of the dwelling. The required air change rate refers to the installed capacity of the system, not the rate of ventilation that is actually used in the house.

Meeting the requirements of this standard would ensure a continuous and controlled supply of fresh air to each dwelling. Each unit would be supplied with fresh air directly, thus ensuring fresh air distribution. However, the amount of outdoor air that can be supplied through infiltration depends on the location of the leakage points, the location of the unit and how isolated the dwelling is from the adjacent unit.

For buildings whose units are relatively well connected to each other, the fresh air change rate of the upper unit due to infiltration is negligible. Exhaust fans are not effective at increasing outdoor air supply to the upper floor unit. Upgrading insulation and air sealing the roof space does reduce the air leakage between dwellings, but exhaust-only ventilation benefits only the lower units.

For buildings whose units are relatively well isolated from one another, exhaust-only ventilation is an effective means of providing outdoor air, especially during mild outdoor temperatures.

Possible solutions include the installation of a balanced mechanical ventilation system or air sealing to increase the airtightness between the units. Although very difficult to install in an existing building, a balanced ventilation system is the most effective means of ventilating the top unit of a building with well-connected units. Another alternative would be to seal the floors and bypasses between the units in order to render them relatively isolated from one another. Both alternatives are seldom implemented.

Since an airtight separation between dwellings is also the goal of fire prevention codes, fire safety will be enhanced if the separations are air sealed. A second bonus to airtight separation is that there is better sound separation if common assemblies do not allow transmission of air borne sound.

Letters to the Editor

Re: Response to Editorial (letters, Solplan Review No. 96, January 2001)

Looks like your editorial struck a nerve with Paul Rawlings at least. However, I think he missed the point. I did not read anywhere in the editorial that you thought that builders were "rolling in the bucks" or were not allowed to make a reasonable profit. On the contrary, I would suggest that if more attention were given to doing it right the first time, in the end total costs would be lower and a happy customer would be a bonus.

As long as industry players look only to defend themselves from these real observations rather than recognize and try to correct problems, they are their own worst enemy.

Doug Lorriman
Georgetown, ON

Re: Editorial (Solplan Review No. 96, January 2001)

I enjoyed your latest editorial. The thought has often occurred to me that we as an industry are not doing all we can. Very bright people have done research, interpreted results, written papers, tested ideas and generally brought the available science and technology to the "available to consumer" level.

Many consumers are benefiting from their R-2000 homes and even more have features added as a direct result of the program. These homes and their features save energy and environmental damage every year for as long as they stand. Unfortunately the converse is also true. Every house built to a lower standard, and every feature not installed, wastes resources and energy every year. Do the arithmetic and you realize the size of the missed opportunities is huge.

We have the technology and skills to do much better. It appears that we will wait a long time for the consumer to demand quality in smaller packages. Why do we build 8' ceilings when most consumers would accept 7'6" especially in bedrooms? Why put in four bathrooms when 2 or 2½ may be more than enough? Why build 3,000 square feet when 2,500 square feet may be more than enough with the proper design?

If we intend to rely on market demand to drive advances then we had better tell the market, in no uncertain terms, what to demand.

Rod Parsons
St John's, NF

Technical Research Committee News

Canadian Home Builders' Association

The Technical Research Committee (TRC) is the industry's forum for the exchange of information on research and development in the housing sector.

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The User's Guide - NBC 1995, Application of Part 9 to Existing Buildings *is available from the National Research Council, Institute for Research in Construction. $47.00*

Tel.: 1-800-672-7990 or 1-613-993-2463

Materials Compatibility

When we build, we assemble a variety of products. In most cases, construction materials are compatible with each other. In the case of traditional materials used for many years, we understand when there may be an incompatibility - such as dissimilar metals used together or near each other that can lead to corrosion and galvanic action.

However, with the increasing use of new synthetic products it is becoming more difficult to assess if dissimilar products are compatible. This is especially a problem with the variety of petrochemical-based sealants and caulking materials used today. Too often there is not enough time to consider whether or not two materials may react with each other.

Problems are not always a mastic or adhesive reacting with another product. We have heard of a case as seemingly benign as roof shingles placed against a roof membrane leading to failure because the two materials were incompatible.

A word of caution to the wise: consider the materials you put together, and if there is the slightest doubt, stop and ask if there could be any incompatibilities you need to be concerned about.

Public Consultation on Objective-Based Codes

As part of preparations for the transition of the national code documents and their provincial counterparts to an objective-based format, the Canadian Commission on Building and Fire Codes, in conjunction with the provincial and territorial ministries responsible for building and plumbing regulation and fire prevention, is conducting a public consultation on a number of issues.

The first public consultation to be conducted under the coordinated national/provincial/territorial code development and maintenance system has been underway. One important benefit of the new approach is that it allows provinces and territories to play a greater role in the process of developing the national code. This will allow for better harmonization of code requirements across Canada through promulgating "core codes" that will contain widely agreed-upon issues that the provinces and territories would not normally have to amend. The new approach also allows for a single coordinated public consultation process.

The consultation papers are available on the Canadian Codes Centre web site. They provide the background and context to assist in formulating responses. Anyone with an interest in the state of the code, and code regulations, especially as the code is evolving to an objective-based one should take a look at this site:

http://www.ccbfc.org/ccbfc/public/dirletter.shtml

Application of the Building Code to Existing Buildings

Additions and renovations present renovators and building officials with a serious challenge, as older buildings often do not comply with current building standards. At what point does the entire building have to be upgraded to today's more stringent codes? Driven by fears of litigation and liability, some local authorities are suggesting that any renovation should trigger a total building upgrade, whether or not it is appropriate.

The Canadian Codes Centre has put together a ***User's Guide - NBC 1995, Application of Part 9 to Existing Buildings,*** that could make life a little easier in these situations. It identifies the basic challenges in trying to apply Part 9 of the NBC to existing buildings and discusses the principles by which NBC requirements should be applied to buildings.

Fifty examples are given of typical problems that may arise in applying specific requirements of the NBC when a building is renovated or its occupancy changed. Solutions to these problems are suggested, along with an explanation of how the alternative design solutions were reached.

The intent of each article in Part 9 of the NBC is provided as well. This listing of intent is the first attempt to explain the meaning of each requirement. It gives code users additional insights into the purpose of each requirement, so that the assessments can be made of the present condition or of an alternative design that may be proposed when requirements for new construction are impracticable to apply.

Steel Framing

The steel industry has led a major campaign to encourage wider use of steel framing in housing. While steel has been used for some time in larger multifamily projects, the number of steel houses and low-rise residential buildings is still small. In the past, home builders who wanted to frame houses with lightweight steel had to comply with Part 4 of the National Building Code, which implied the need to hire professionals to design the structure and details. This extra cost has been one barrier to the widespread adoption of steel when appropriate.

The steel industry has now standardized components and has produced technical guides and design manuals that should eliminate the need for professional structural design services for many smaller structures. The Canadian Sheet Steel Building Institute (CSSBI), together with the CCMC have produced a technical guide that establishes performance criteria for small buildings. These include structural performance, heat transfer, air leakage and condensation control. The CCMC evaluation and technical guide should make it easier for builders to use steel when they feel it appropriate.

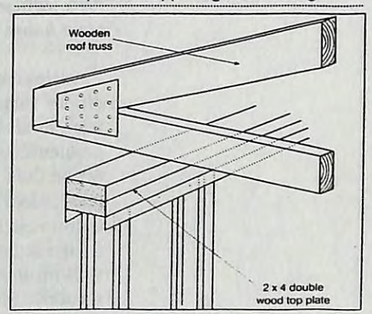
A ***Residential Steel Framing Member Selection Tables*** manual provides tables for steel studs and joists, not unlike the tables in the present code for wood framing.

A ***Residential Steel Framing Installation*** manual provides information and details for the correct assembly and installation of steel framing. The framing of roofs with lightweight steel is not included in the scope of the manual. However, it does mention that any type of wood roof framing can be used with steel-framed construction. Wood roof framing reduces the thermal bridging in that part of the structure, so from a purely thermal point of view, may be preferable to all steel roof trusses.

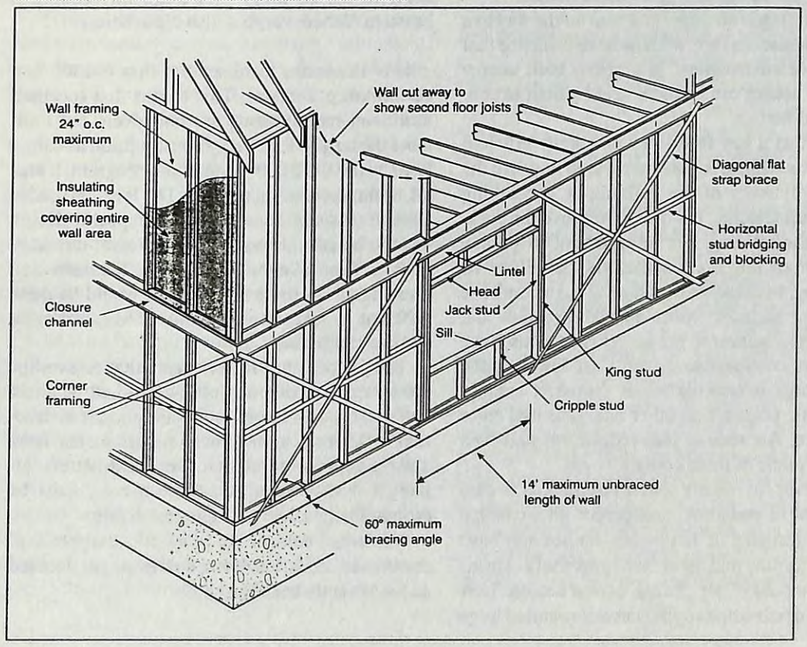
It is important to remember that thermal bridging through steel framing is much more severe than through wood, so special attention must be given to the design and detailing of thermal breaks.

Information:
Canadian Sheet Steel Building Institute
Tel: 519-650-1285
Fax: 519-650-8081
www.cssbi.ca

Double Top Plates Supporting Roof Framing



Wall Framing



Debunking the Myths of Energy Efficient Housing

The myths about R-2000 and energy efficient housing that persist to this day are amazing, despite the many years of experience we have and the many satisfied residents. We have indisputable evidence that R-2000 homes are not only energy efficient, but also healthier for their occupants. Nevertheless, similar questions are raised again and again.

"It's difficult to breathe inside an energy efficient home."

Increasingly, people are affected by health conditions such as allergies and asthma that are related to air quality. For people with respiratory problems, indoor air quality is more an issue of health than comfort. Every home should provide good indoor air quality for everyone living in it, but unfortunately that is not always the case. The design strategies for good indoor air quality and well-insulated airtight R-2000 houses are complementary. Studies done by CMHC have shown that even old drafty houses have poorer indoor air quality than newer energy efficient homes.

Air sealing is an important step on the way to a healthy house. In fact, we now have evidence that the indoor environment in properly built energy efficient houses can be more healthy than in conventional houses.

It is also a key feature of an energy efficient house. Air sealing is done not just to improve the energy efficiency of the building by controlling random air leakage, but also to improve the durability of the building. It is the uncontrolled leakage of indoor air into the construction that affects its durability, because warm moist air can condense on colder surfaces within the construction and allow deterioration to set in. Airtight houses are also more comfortable, as there are fewer drafts. Air leakage is also the major source of outdoor pollutants, pollens and other allergens that enter the house. Air sealing thus reduces uncontrolled entry of many of these contaminants.

However, as we air seal a building, it is also important to recognize that proper air exchange must be designed in. In the past, houses may have been very drafty and, by default, provided a considerable amount of air change over a season. Less efficient combustion appliances also required large air-flows up their flues to remove combustion gases, so the combustion appliances themselves helped draw and move air through and out of the house. In essence, they were part of a very inefficient ventilation system.

Designed ventilation systems were a hallmark of the earliest energy efficient demonstration houses in Canada. Ventilation must be designed into the house. This means that builders must include an appropriate ventilation system as part of the design, and the system must operate continuously. If the major portion of outdoor air enters through the ventilation system, there will be an opportunity to filter that air. The evidence now tells us that homes with a properly functioning ventilation system will have superior indoor air quality.

Builders can take advantage of the features of a well-designed house with a good ventilation system to promote awareness of superior indoor air quality as an educational and a sales tool.

"It's mild here, so the economics of R 2000 don't apply to us, do they?" (A frequently comment heard in Vancouver, but also elsewhere.)

It is important to remember that R-2000 is a performance standard. This means that specified minimum requirements are not given, but must meet the targets for energy consumption as calculated by the HOT 2000 simulation program. It also takes into account solar gains. The formula used is climate sensitive: for example, if a specific design were to be considered for two different climates, such as Vancouver and Edmonton, the insulation levels required in the two houses would be quite different to take into account the very different climate conditions.

The performance factors mean that on average the energy consumption of R-2000 will be about half that of conventional code compliant construction. Reviews of technical requirements have always kept in mind that the construction, although it may entail a premium cost, must be economically achievable and justifiable.

Of course, none of the economic analyses ever considered scenarios where energy prices doubled as has recently been the case.

R-2000

For information on the R-2000 Program, contact your local program office, or call
1-800-387-2000
or
1-613-947-200

Marketing: What is the Message We Are Really Sending?

For some time we've been saying that as an industry we have to become more active in the public debate about housing design. We have to be proactive to change public attitudes and create realistic expectations about the products we produce.

This piece by Jack Parsons is an edited version of a script he uses in sales seminars. We thought this is an amusing way of looking at how we approach our customers. It offers interesting insights about how we market ourselves and our products, and in the process help influence public perceptions.

Last weekend we set out on a shopping trip. First call was the grocery store for some munchies. Printed clearly on the packet was a list of ingredients and the warning "contains nuts." Not being afflicted with any allergies, we made our purchase and left. My partner commented that it was thoughtful of the vendor to place the warning on the packet. Being more a cynic, I pointed out that consumer protection laws forced vendors to print the warning

Another purchase, for later consumption, was a frozen dinner for two, which according to the label, needed one hour in the oven to thaw out. We have been on a strict budget for some time so my partner, an accountant, quickly calculated the cost of thawing our dinners and concluded that we could afford them, thanks to the information printed on the package.

Our next call was to the car dealership where we were determined to get the best deal possible. We had agreed that I would select on the basis of colour, safety features, comfort, style, and trunk space while my accountant partner would deal with all the money items.

My selection process was tense at times because there were so many decisions to make. Fortunately, the salesperson was helpful and volunteered opinions on all my picks. I am amazed that every decision I made was exactly the one he would have made if it were his own car. His taste, which he considered quite refined, coincided exactly with mine. My partner asked about things such as maintenance costs, gas mileage, tire life expectancy, warranty and repair costs. I was amazed at the things my partner asked. I would never have remembered to ask them despite reading somewhere that you should.

The salesman, after complimenting my partner for being such a discriminating and careful consumer, produced beautiful pamphlets and an operating manual. We found all the information needed, displayed clearly. There were comparison numbers for other products and tips to help us get the most out of our purchase, and what it would cost to operate our new car. The salesman pointed out stickers on the car, which also gave this information in case we lost the manual. My partner got right into the numbers, but soon questioned their validity, as they were all supplied by the people trying to sell us the car.

To convince us that the information was as accurate as it could be, the salesman, who had obviously answered the question before, pointed to the various testing agencies, standards associations and government departments who insist on the information being displayed.

We then discussed a financing option, but once my partner saw the cost of borrowing on the required disclosure form, we decided that it was too much and paid in full by direct debit.

With food and transport taken care of, we were ready to look for a new house. On the way to the new development, we planned our purchase strategy. This time my partner would deal with the visual things and I would ask the money questions. Even though I am not an accountant, my partner felt sure I would be fine since it would only be a matter of reading the charts and adding up the monthly costs.

We were impressed by the size of the house and the features in the kitchen. The house was very tastefully decorated. We could picture our own furniture in place. I was prepared and even had a few questions. The first was "how much will the heating bills be each month?" This generated an informative dissertation on 2x6 walls as opposed to 2x4 which were used on older houses.

The second time I asked the question, I expected to be shown the chart (similar to the one for our new car) but this time we were treated to window information. It seems that some windows lose a lot of heat. Quite obvious, I thought, as you can even see through them, but the ones in this house were very advanced and actually gained more than they lost. We were a little confused at this point. Did this

mean that if we made the windows really big we could get rid of all the heaters?

The salesperson produced a pamphlet. Unfortunately, it only explained something called a window rating. I'm sure it was well done, and explained windows well, but there was not a dollar sign anywhere, so I was unable to relate the rating to heating costs.

The third time I asked about heating costs, we were led to the basement where we were introduced to the heat recovery ventilator. The salesperson assured us it would ensure that the heating costs would be lower than if we did not have one.

"Lower than what?" I asked.

Eventually, we discovered that the local power company would do a heat loss calculation for us if we took the plans to them, but it would take a few days. The salesperson rang the builder who was able to remember the power bills on a very similar house on the same street. These were copied down and finally I had my information.

The salesperson then told us that there was a house type called R2000, which was supposed to be more energy efficient but cost more. My partner said that our budget limit had been reached and so, despite something the salesperson said about payback, which I thought would interest my partner, we signed up and paid by VISA. If we paid the VISA bill in full in thirty days, there would be no interest, which was a great saving compared to the mortgage schedule the salesperson showed us.

As we left to get our furniture, a figure ran from the side of the house and proceeded to beat us over the head with a 2x4. We were shocked and asked what it was all about.

"My name is Market Driver, and I am sorry I am late," he said rather sheepishly. "It's my job to get to you before you buy and convince you to demand the most energy efficient house available, or at least a full information package about just what is available and the cost of ignorance."

Thermostat Settings in Houses With In-floor Heating

Radiant in-floor heating has become a popular heating system alternative in many parts of the country. It is very pleasant to have warm floors when the weather is cold outside. As well, radiant systems offer an alternative to the air movement associated with forced air systems.

A common claim by those selling in-floor heating systems is that radiant systems are more energy efficient than more conventional heating systems. The theory is that with warm floors and higher mean radiant temperatures, people will set their thermostats lower. These lower temperatures will thus lead to energy savings. However, is there any basis of truth to these claims? A recent CMHC study looked at whether the thermostats in houses with in-floor heating were actually set lower than in comparable houses with conventional heating systems.

A number of new houses in Nova Scotia were surveyed. Fifty houses had radiant in-floor heating while 25 were houses that other heating systems (forced air, hot water baseboard, etc.). The types of heating system and the main floor thermostat setting, during daylight hours on the weekend, were checked.

Generally there are no energy savings due to lower thermostat settings with in-floor heating systems.

What was found?

Homeowners with radiant in-floor heating systems do not set their thermostats significantly lower than homeowners with other types of heating systems. The main floor thermostat settings for the 50 houses with radiant in-floor heating systems averaged 20.4° C. The main floor thermostat settings for the 25 houses with other heating systems averaged 19.8° C. These temperatures are virtually the same as was observed in several other house surveys done in earlier surveys, where the measured temperatures in Nova Scotia houses with forced air systems averaged from 19.9 to 20.2° C. for daytime settings, and an evening setting of 20.6° C.

What this study shows is that generally there will be no energy savings due to lower thermostat settings with in-floor heating systems. However, energy savings are still possible because in-floor systems are more likely to be zoned.

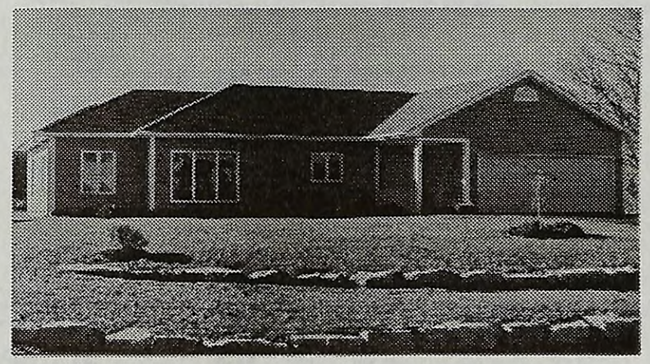
Envirohome: Comfortable and Affordable Housing

Steven Crowell of Crowell Construction, Kentville, Nova Scotia, has shown that a home combining sustainability, energy efficiency and healthy housing features can be incorporated into an affordable and comfortable home. His Envirohome project was designed to meet the needs of a retired couple. It fits into the growing market niche of a Canadian population that is increasingly concerned with indoor air, quality barrier-free design, and comfort in an affordable package.

Crowell's Envirohome98 is more energy efficient than a comparable conventionally built home, and exceeds minimum R-2000 standards. It incorporates solar energy, thermal mass heat storage and energy efficient design. Also included are low-cost, subtle enhancements to the home such as wider doorways to help it accommodate people with special needs. Future renovations can be easily and affordably accomplished because the design has no interior load bearing walls.

A significant reduction in the impact on the environment was achieved at no cost to the home owner. All materials used to build the house were analysed for recycled content and what impact they would have on the environment. Even the nails were selected for their recycled content.

The Envirohome98 was the winner of the Concept and Design category of CMHC's Year 2000 National Housing Awards.



How Parks Influence the Climate in Their Neighbourhood

Historically parks have had many functions, from being "only" an aesthetic urban feature to protecting a town from fire by creating an open buffer area between buildings (one reason behind many zoning regulations). In recent years attention has focused on how open spaces can be used in planning for sustainable urban development. An interesting point is how parks influence the climate in their vicinity.

We already know that urban areas create their own climate. The temperature difference between a city centre (the urban heat island) and the country can average 5°C.

Research at Goteborg University in Sweden on urban climate since the 1970s has shown just how much impact parks can have on their surroundings. The Swedish researchers found that parks really do work as the lungs of a city. The temperatures inside and around the park vary as does the air quality. A park can also create its own wind system.

Large parks (156 ha) may be as much as 5.9°C cooler than their surroundings, especially on clear nights when wind speeds are low. Even smaller parks of only one or two hectares may be up to 2°C cooler than the surrounding built-up area. Daytime temperature differences are smaller than at night, and the temperature variations are largely dependent on the density of the built-up area and the park.

The cooling effect of a large park may extend more than 1,100 metres from the park boundary. On hot summer days the cooling effect is positive, but in winter it can be a negative because it may increase the energy needed for heating in buildings near the park.

It has also been noted that at night the temperature difference between a park and buildings can generate its own breeze. This "park breeze" occurs during calm and clear nights when the temperature difference between the park and the built-up area is greatest, and can carry fresh air from the park into

Continued on page 17

Energy Answers

Rob Dumont

Is there one manufacturer who consistently produces the most energy efficient appliances on the market here in North America?

The short answer is no.

In the area of mutual funds, one can safely steer friends and relatives to low MER index funds. In the appliance area, there is unfortunately no similar guidance one can offer.

Table 1 lists the most energy efficient appliances on the Canadian market as of 2001, according to the Canadian ENERGUIDE Directory.

Table 1

The Most Energy Efficient Appliances on the Canadian Market

Appliance Type	Manufacturer	Annual Energy Consumption *(kWh)*
Refrigerator with top freezer *(14.5 to 16.4 cubic feet)*	Magic Chef	437
Freezers *(chest type 13.5 to 15.4 cubic feet)*	14 Brands	437
Ranges *(self-cleaning 30 inch width)*	Amana	639
Dishwashers *(Built-in, Standard size)*	Asko	381
Clothes washers *(75 litre tub capacity)*	Frigidaire	259
Electric Clothes dryers *(198 litre drum capacity)*	Beaumark, GE, Fisher Paykel, Hotpoint, Moffat	898
	Total	3051

As you can see, there is no one manufacturer who is the leader in all of these categories.

Electricity prices do vary considerably across the country. As of 1997, electricity prices in Canada ranged from a low of 6 cents per kWh in British Columbia to a high of 11.8 cents per kWh in P.E.I.

Table 2 presents a comparison of the best and the worst energy performers.

The ENERGUIDE Appliance Directory is available free of charge by calling the toll-free number 1-800-387-2000.

As you can see from the table, choosing all of the worst performing appliances would increase your consumption by 50% compared with the best performers.

With some appliances, like freezers and electric clothes dryers, there is little difference between the best and the worst. On the other hand, for refrigerators, ranges, dishwashers and clothes washers, there can be very large differences between the best and the worst.

Front loading clothes washers as a class are dramatically more energy efficient than the top-loading variety. Another advantage of the front loading clothes washers is that they tend to have higher spin velocities (one unit goes as high as 1800 rpm) which will mechanically extract more of the water and consequently reduce the amount of energy that the clothes dryer must provide.

Considerable progress has been made in improving the energy efficiency of some appliances over the years. According to the ENERGUIDE Directory, the refrigerators and freezers built today are 53% more energy efficient than those built in 1984. Dishwashers are 26% more energy efficient.

Much, however, remains to be done. For instance, the US company Sunfrost produces a 16 cubic foot refrigerator-freezer for photovoltaic applications that uses only 197 kWh per year, or 55% less energy than the best conventional refrigerator on the Canadian market.

Table 2

Best and Worst Energy Performers

Appliance Type	Best Annual Energy Use *(kWh)*	Worst Annual Energy Use *(kWh)*	Ratio of Worst to Best
Refrigerator with top freezer *(14.5 to 16.4 cu. ft, automatic defrost)*	437	565	1.3
Freezers *(chest type 13.5 to 15.4 cu. ft.)*	437	441	1.0
Ranges *(self-cleaning 30 inch width)*	639	858	1.3
Dishwashers *(Built-in, Standard size)*	381	698	1.8
Clothes washers *(75 litre tub capacity)*	259	1000	3.9
Electric Clothes dryers *(198 litre drum capacity)*	898	950	1.1
Totals	3051	4512	

Continued from page 15

the town. Calm and clear nights can also cause inversion which often creates poor air quality.

The purifying effect of a park on the air quality was noted by looking at the concentrations of two VOCs: benzene and toluene. When wind speeds were low large variations in benzene and toluene concentrations were measured over a few metres, for instance between the two sides of the street.

In a larger park, concentrations of hydrocarbon pollutants (generated by street traffic) rapidly decrease the further inside the park measurements are made. Concentrations as close as 40 metres away from the street fell to those measured at the street. Even in a small park surrounded by heavy traffic the air is on the whole cleaner than in its surroundings.

As our cities become denser, for the social, transportation, and community benefits, it is important to remember the climatic and air quality benefits of green spaces. Traditional North American suburban sprawl adds more paved surface and traffic than may be wise, and may offset the benefits of green spaces.

Confused about the different home automation standards?

There is more home automation today, or at least homes are increasingly being pre-wired. But is there a common automation standard? Do all the systems have interchangeable components, as do lights, heating systems, electrical motors and tools?

Good questions, as there are at least 24 automation protocol/standards groups. That is why the Continental Automated Buildings Association [CABA] has undertaken to encourage industry-wide interchangeability of protocols and standards..The CABA Standards Committee will create a summary profile for each protocol and standards group. As the profiles are completed, they will be posted on the CABA web site (*http://www.caba.org*), so that industry can learn about and compare the different home automation standards and protocols posted.

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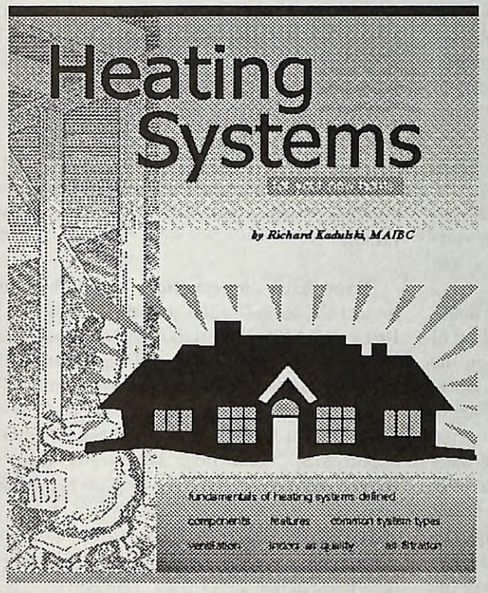

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NRC·CNRC

IRC develops new software for designing to minimize aircraft noise

By J.S. Bradley

The IRC has almost completed a three-year project that will give architects and builders a new and better design tool for insulating buildings against noise from aircraft.

The need for the ***Insulating Buildings Against Noise from Aircraft*** (IBANA) project stemmed from the fact that existing information has become virtually obsolete because of changes in Canadian construction practice - for example, thicker walls with more thermal insulation, which could improve sound insulation, and increased venting of attic spaces, which could reduce it. As well, aircraft have changed - newer commercial jet aircraft are quieter than their predecessors but have different noise characteristics.

There are three major components to the project: The first was laboratory tests of the sound insulating properties of building facade elements, including various wall and roof constructions. In doing these tests, the frequency range of measurements was extended to include the important lower frequencies - aircraft noise levels can be quite strong, but measurements at these lower frequencies had not previously been carried out. The results are included in a report that can be obtained from IRC.

The second part of the project involved field measurements of the sound insulation of various constructions exposed to real aircraft noise. Systematic variations, such as the number of layers of gypsum board or the size of windows, were made to a test house constructed at the Ottawa airport. Measurements were also made on various existing buildings near the Toronto and Vancouver airports.

The results from the Ottawa airport test house are being used to gain a better understanding of the factors responsible for the difference in the sound insulation ratings obtained in the laboratory and those from actual buildings exposed to real aircraft noise.

In the laboratory, the sound insulation of walls or roofs is measured in ideal test conditions in which sound strikes the test specimen more or less equally from all directions. In real buildings aircraft noise strikes the building facade from a range of angles, which depend on the orientation of the facade relative to the flight path. The matter is further complicated by the fact that aircraft do not radiate sound equally in all directions and tend to be much louder when moving away from a building than when approaching it.

The third component of the project is development of a Windows-based software that will be more accurate and easier to use than previous design procedures. Sound insulation calculations are based on the characteristics of the aircraft noise, sound insulation ratings and areas of the various facade elements. To be accurate, and meaningful, the calculations must be repeated for a wide range of frequencies and take into consideration differences between laboratory and field conditions.

The new software includes a database of more than 100 sound insulation measurements and allows the user to compare various design solutions to quickly and conveniently arrive at an optimum design. Users can add new sound insulation and aircraft noise data, making the program even more useful. In addition to calculations in decibels, there will be audible simulations of aircraft sounds experienced indoors for selected design examples. This means that the user will be able to listen to the differences between design options as well as look at the numbers.

All components of the project, including the software and an accompanying manual, are expected to be complete by mid-2001 and will be made available for a nominal fee. Notification of availability will be provided in Construction Innovation.

If you have any questions about this work, contact Dr. John Bradley at 1-613-993-9747, fax 1-613-954-1495, or e-mail *john.bradley@nrc.ca.*

To purchase a copy of the full report presenting detailed results from the research, contact IRC Client Services at 1-800-672-7990 (1-613-993-2463, Ottawa-Hull and U.S.) and ask for Internal Report 818, "*Laboratory Measurements of the Sound Insulaton of Building Façade Elements.*"

This project was undertaken with the support of the Department of National Defence, Transport Canada and the National Research Council, with additional support from Vancouver International Airport.

This article was reproduced from IRC's newsletter, Construction Innovation, Winter 2001, p. 1, 11.

Dr. John Bradley is a senior research officer (acoustics) in the Indoor Environment Program of the National Research Council's Institute for Research in Construction.

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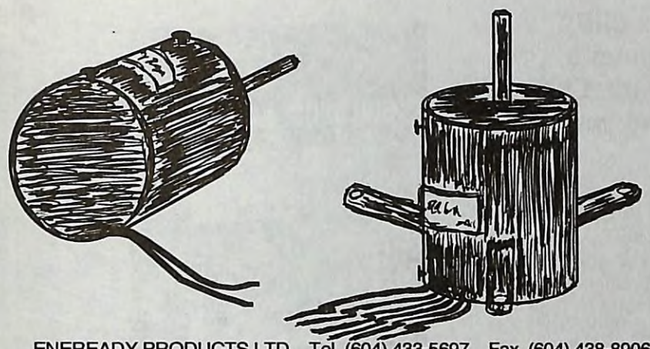

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Tel: 952-881-1098
Fax: 952-881-3048
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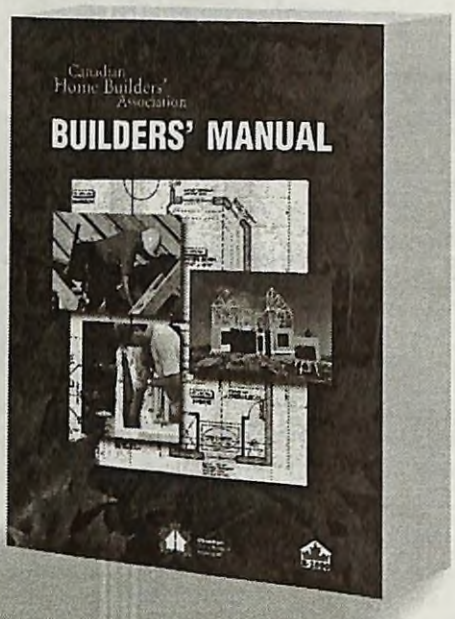

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